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Full Length Research Paper

Effect of dietary inclusion of whole sunflower seeds on feeding lactating Zaraibi goats: Milk production and composition as well as mammary gland histology and economic efficiency

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The present study aimed to evaluate the effect of replacing concentrate feed mixture containing cotton seed cake by 15 or 20% of whole sunflower seeds on milk production and composition as well as economic efficiency of does. A total of 30 local breed (Zaraibi) goat does from 4-5 years of age, with an average of 42.46±0.86 kg LBW and within 3 parity were used in this study. Does were fed a basal ration consisting of 25% concentrate feed mixture (CFM) beside 75% fresh berseem during winter feeding or 50% CFM and 50% berseem hay (BH) during summer feeding. During the last month of pregnancy, all does were divided into three groups (10 does each). Goats in the 1st group (G1) served as a control and were fed the basal ration (Control). However, does in the 2nd (G2) and 3rd (G3) groups were fed the control ration, but 15 and 20% of CFM were replaced by whole sunflower seeds, respectively. Average daily milk yield during the suckling period was the highest (P<0.05) in G3 as compared to G2 or G1. The significant differences were observed only at 60, 75 and 90 day of the suckling period. At 90 days of the sucking period and during the whole milking period, average daily milk yield was higher (P<0.05) in G2 and G3 than in G1. The present results revealed that feed cost of production of each kg milk was the lowest (1.44 L.E.) for does fed 20% SFS ration, the modest (1.59 L.E.) for those fed 15% SFS ration and the highest (2.02 L.E.) for the control does. Based on the foregoing results, the tested rations (15 and 20% whole sunflower seeds) in the treatment groups resulted in increased milk production without remarkable changes in milk composition.

Key words: Goats, sunflower, milk, economics.

INTRODUCTION

Goats are an important source of meat and milk. Recently, goats became an important aspect of animal production in Egypt. Increasing productivity of goats will contribute to improve the standard of living of the rural people. Ruminants have unique ability to utilize the fibrous material through anaerobic fermentation, therefore, sunflower seed meal (SFM) can be efficiently used as a sole source of supplemental protein for ruminants (Lardy and Anderson, 2002). Cottonseed cakes (CSC) are being traditionally used as a feed for dairy animals. However, limited supply and seasonal availability of CSC result in high price. On the other hand, SFM is cheaper protein source and can be used as ruminants feed supplement (Yunus et al., 2004). To cover the various nutrients in goats, energy and protein, the feed concentration should be increased, as these dairy animals have a smaller rumen capacity. Oilseeds (sunflower) contribute to increase energy intake of goats and defatted oilseeds in the diet increase of the protein intake (Antunac et al., 2001). Traditionally, the farmers

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have been using cottonseed cakes for feeding their livestock as a source of vegetable protein and its prolonged use can affect the fertility of these animals (Zahid et al., 2003). Earlier investigations (Ahmed et al., 2004) indicated that sunflower meal was equally good in performance, yet the cost of sunflower meal based rations was the lowest. Dietary lipids supplementation, as whole crude oilseeds, may also indeed change fatty acids composition of milk that is one of the most important factors influencing technological and nutritional quality of goat milk (Chilliard et al., 2003). Therefore, the present study was conducted on does to evaluate the effect of replacing concentrate feed mixture containing cotton seed cake by 15 or 20% of whole sunflower seeds on milk production and composition, as well as economic efficiency.

MATERIALS AND METHODS

This research is the second part of a serial number of studies on Zaraibi goats (an Egyptian breed) fed a basal ration consisting of 25% concentrate feed mixture (CFM) beside 75% fresh clover (berseem, *Trifolium alexandrinum*) during winter feeding or 50% CFM and 50% berseem hay (BH) during summer feeding. Goats of all groups were given the NRC feeding requirements (NRC, 2001) for production of 1-2 kg milk/head/day. The daily feed intake per doe composed of 1.250 kg CFM at 8.00 a.m. + 4 kg green berseem or 1.3 kg berseem hay twice daily (11 a.m. and 3 p.m.). At the late stage of pregnancy (last month of pregnancy), all experimental does (n=30) were divided into three experimental groups according to their age, weight and milk production. Goats in the 1st group (G1) served as a control group and were fed the basal ration (control). However, does in the 2nd (G2) and 3rd (G3) groups were fed the control ration, but 15 and 20% of CFM was replaced by whole sunflower seeds, respectively. The chemical composition and digestibility of the tested rations and their effects on the rumen liquor parameter are shown in Table 1.

Hand milking was carried out twice at the day of milking (6 a.m. and 5 p.m.). Milk yield was individually measured, recorded and milk samples were taken for chemical analysis. The total milk yield for a doe at the day of milking was considered to represent average daily milk yield during the previous two weeks. During the day of milking, kids were removed from their dams and allowed to suckle other goats. After the end of the suckling period, machine milking was applied for all experimental groups up to the end of lactation. Milk yield was individually measured and milk samples were collected every two weeks by means of such milk meter for chemical analysis. Each doe was dried up when her daily milk yield declined to 200 g for three successive days.

Milk samples (100 ml each) were taken biweekly for chemical analysis. During the suckling period, at the day of hand-milking, the morning milk from goats of each breed group was cooled at 5°C, added to the evening milk, well mixed and representative samples were taken. During machine milking period, morning cooled milk samples were added to the evening ones, and the representative breed group samples were taken. Milk samples were analyzed for fat, total protein, lactose and total solids using Milko-Scan (133B N. Foss Electric, Denmark). However, somatic cells count in milk was determined according to standard methodology stated by Marshall et al. (1993) using a Fossomatic cell counter (NS N. Foss Electric, Hillerød, Denmark). Lipid extraction was conducted according to the methods of A.O.A.C. (2000) using chloroform / methanol (2:1, v/v).

The histology study was conducted pre- and post-suckling as well as pre-milking during the milking period. Biopsied samples from the middle region of the mammary gland of three does of each group were taken using scalpel with disinfectant surface and about 0.25 g of the tissue was removed into a sterile glass, and after which 5 ml of salt solution + 5% formalin solution were added. A complete dehydration of the mammary tissue samples was accomplished by soaking mammary tissue in 60, 70, 80, 90 and 95% ethanol lasting two hours for each level, followed by two soakings in absolute ethanol (100%) for one hour each. Tissues were then cleared in xylol for not more than two hours, and were transferred to melted paraffin wax (m.p. 52°C) for three hours in a thermostatically controlled oven. Mould brass was filled with fresh melted wax in which mammary tissues were embedded, oriented carefully and cooled rapidly in cold water. The wax blocks were then stored in refrigerator until sectioning. The mammary tissues were sectioned at 5-7 µm, mounted on glass slides smeared with albumin and glycerol (1:1). Slides were placed on a hot plate at 45°C to expand the sections and left overnight in an oven at 37°C to dry completely. Sections were immersed in xylol for overnight and then transferred to descending grades of ethanol from 100% until 50%. Ehrlich's haematoxylin and aqueous eosin 1% were used for staining for three minutes and one minute, respectively. Slides were washed in running tap water for ten minutes after haematoxylin and two minutes after eosin. Section were taken up through ascending strengths of 50 to 100% ethanol, then cleared in xylol and mounted in Canada balsam.

Data obtained in this study were subjected to statistical analysis using General Linear Models Procedures (GLMP) adapted by SPSS for windows (2004) for user's guide. Duncan test of SPSS programme was done to determine the degree of significance between the means at $P<0.05$.

RESULTS AND DISCUSSION

Milk production

Milk yield

Average daily milk yield during the suckling period

Table 1. Chemical composition of different feed ingredients and experimental rations.

Item	DM (%)	Chemical composition (%) on DM basis					
		OM	CP	CF	EE	NFE	Ash
Feed ingredients							
CFM	89.95	87.76	14.40	7.08	2.40	63.88	12.24
SFS	85.65	96.91	11.91	8.08	14.66	62.26	3.09
FB	17.06	88.59	16.65	20.98	2.35	48.61	11.41
BH	86.19	89.19	12.65	27.85	3.41	45.29	10.81
Calculated composition of winter ration (R)							
R_1 (G_1)	34.41	88.07	15.24	12.32	2.37	58.14	11.93
R_2 (G_2)	34.26	89.43	14.86	12.47	4.20	57.90	10.57
R_3 (G_3)	34.21	89.90	14.74	12.51	4.82	57.83	10.10
Calculated composition of summer ration (R)							
R_1 (G_1)	88.27	88.36	13.63	16.09	2.83	55.81	11.64
R_2 (G_2)	87.91	89.73	13.25	16.24	4.66	55.58	10.27
R_3 (G_3)	87.80	90.19	13.03	16.28	5.28	55.6	9.81

CFM: Concentrate feed mixture; SFS: Sun flower seeds; FB: Fresh berseem; BH: Berseem hay.

Table 2. Effect of feeding the experimental rations on milk yield (mean ± SE) of Zaraibi goats during the suckling and milking periods.

Period (day)	Experimental group		
	G1	G2	G3
Average daily milk yield (kg/day) during the suckling period (day)			
15	3.17±0.16	3.33±0.27	3.77±0.29
30	2.81±0.30	3.19±0.34	3.50±0.21
45	2.50±0.15	2.90±2.80	3.04±0.39
60	$2.14±0.15^{b}$	$2.59±0.16^{b}$	$3.13±0.20^{a}$
75	$1.92±0.18^{b}$	$2.40±0.14^{b}$	$2.96±0.20^{a}$
90	$1.69±0.15^{c}$	$2.29±0.14^{b}$	$2.79±0.16^{a}$
Average daily milk yield (kg/day) during the milking period (day)			
120	$1.59±0.14^{b}$	$2.20±0.15^{a}$	$2.52±1.40^{a}$
150	$1.40±0.13^{b}$	$2.23±0.13^{a}$	$2.54±2.21^{a}$
180	$1.40±0.13^{c}$	$1.96±0.16^{b}$	$2.12±0.13^{a}$
210	$0.96±0.10^{b}$	$1.66±0.13^{a}$	$1.83±0.15^{a}$
240	$0.76±0.08^{b}$	$1.13±0.09^{a}$	$1.29±0.09^{a}$
Total milk yield (kg/doe)			
Suckling period	213.39^{c}	259.38^{b}	287.73^{a}
Milking period	149.76^{c}	219.96^{b}	247.08^{a}
Whole period	363.15^{c}	479.34^{b}	534.81^{a}

a, b and c: Means within the same row with different superscripts are significantly different at P<0.05.

(biweekly) and milking period (monthly) as affected by dietary treatment is presented in Table 2. Average daily milk yield during the suckling period showed significant (P<0.05) differences as affected by dietary treatment, being the highest for does fed 20% SFS ration as compared to those in 15% SFS or the control group. The significant differences were observed only at 60, 75 and 90 days of the suckling period. At 90 days of the sucking period and during the whole milking period, average daily milk yield was significantly (P<0.05) higher for does in both treatment groups than that for the control does, but does in 20% SFS group showed significantly (P<0.05) higher yield than those in 15% SFS (Table 2).

It is of interest to observe that does in all groups showed similar trend of change in milk yield throughout different lactation weeks, being the highest at 2 weeks of lactation and the lowest at the end of lactation period (Table 2). Soliman et al. (1995) found that fat corrected milk yield was increased significantly (P<0.05) between weeks 1 and 3 of lactation, thereafter fat corrected milk decreased rapidly after three weeks till the end of the lactation period. They suggested that these changes in the milk yield and composition during lactation period may be due to the level of prolactin hormone secretion, efficiency of the udder secretory cells and some other factors. Such trend was also found in Zaraibi goats and several breeds of goats as reported by many authors, with variable timings and levels of the production peak and variable rates of change in milk yield with lactation advance (Hassan et al., 2012).

The reviewed studies on the quantitative milk production in lactating dairy goats indicated almost similar trend of changes in daily milk yield. Lactation starts high after kidding, daily increase in milk yield continues and peak is reached within many weeks. Then, the lactation curve declines almost linearly. Rate of decline increases with lactation advance up to the attainment of minimal milk yield values when goats were dried up.

Based on total milk yield, does in 20% SFS group showed significantly (P<0.05) the highest milk yield during the suckling period, milking period or both periods. Does in 15% SFS group ranked second, concerning the corresponding values, but were significantly (P<0.05) lower than those fed 20% SFS. Such findings indicated marked increase in total milk yield of does as level of SFS substitution increased from 15 to 20%. The rate of increase in total milk yield was 21.55 and 10.92%, 46.75 and 12.32%, and 31.99 and 11.57% in 15 and 20% SFS groups as compared to the control group during the suckling, milking and both periods, respectively (Table 2). Interestingly, it was observed that the noticed improvement in milk yield of does fed 20% SFS ration was associated with increasing digestibility coefficients of most nutrients and nutritive values of this ration as compared to other rations.

The present results of milk yield are in agreement with those obtained by Giaccone et al. (1995) on Derivata di Siria goats in Sicily. On the contrary, Ciappesoni et al. (2002) observed higher average milk yield (2.58 and 2.93 kg/day) for the white and brown Czech breeds, respectively. As affected by feeding diets supplemented with sunflower oilseeds in Zaraibi goats, El-Sanafawy (2008) found that daily milk yield for control, 5% sunflower and 10% sunflower groups gradually decreased from 1.83, 2.10 and 2.07 kg/day at the 1st lactation month to 1.43, 1.54 and 1.87 kg/day at the end of the 4th month, respectively. Also, Hassan et al. (2012) revealed insignificant differences in milk yield of Zaraibi goats neither between treatment groups fed diets supplemented with calcium soap of fatty acids from soybean, cotton seed or palm oils and control group nor among treatment groups during suckling period or milking period, except for that during the first 30-day post-partum, milk yield of does fed soybean oil diet was significantly (P<0.05) higher than those of control and other treatment groups. Average daily milk yield ranged from 2.098-2.397 kg at 15 days of kidding to 1.090-1.347 kg at weaning (90 days post-kidding) and to 0.845-0.883 kg at 120 days post-kidding. These results are similar to those reported by Otaru et al. (2011) on goats fed fat supplemented diets.

Milk composition

Fat content

Effect of feeding the experimental rations on fat content in milk of Zaraibi goats during the suckling and milking periods is shown in Table 3 which presents that the differences among the experimental groups in fat content of goat milk were not significant during the whole lactation period, except at the end of the suckling period (90 days of lactation). Fat content was significantly (P<0.05) lower in both treated groups than that in the control and at 150 days of lactation (milking period), fat content was significantly (P<0.05) higher in does of G2 fed 15% SFS ration than that in those fed 20% SFS ration (G3) and control ration (G1).

Hassan et al. (2012) found that fat percent did not differ significantly by dietary supplementation of different types of plant oils. However, EL-Sanafawy (2008) found that diets contained 5 or 10% SFS increased fat content in milk of Zaraibi goats from 2.99-4.07% in the control group to 3.51-4.14% in 5% group and 3.20-5.24% in 10% group. In local Barki goats and their crosses with Damascus, Eissa (1996) showed that the fat percentage in milk of Barki does decreased from 5.11% in the first week to 4.24% in the 8th week (suckling period) and increased to 5.67% at the end of milking period. They added that fat percentage in milk of Damascus decreased from 3.86 to 2.99% in the suckling period (the first eight weeks) and increased to 4.72% in the end of milking period. Milk fat content was high after parturition and then decreased during the major part of lactation in the goat. This is related to a dilution effect due to the increase in milk volume until the lactation peak. Negative regression coefficients of fat on total milk yield were found in Jamnapari goats (Pal et al., 1996).

Table 3. Effect of feeding the experimental rations on fat content (%, mean ± SE) in milk of Zaraibi goats during the suckling and milking periods.

Period	Experimental group		
	G1	G2	G3
Suckling period (day)			
15	5.58±0.21	6.21±0.28	5.53±0.32
30	5.95±0.40	5.69±0.27	5.23±0.36
45	5.38±0.26	5.53±0.22	4.73±0.34
60	6.28±0.42	5.69±0.31	5.42±0.30
75	5.47±0.34	5.14±0.26	5.08±0.27
90	5.46±0.22[a]	4.48±0.21[b]	4.60±0.20[b]
Milking period (day)			
120	4.26±0.31	4.50±0.18	4.22±0.11
150	3.27±0.17[b]	4.04±0.17[a]	3.51±0.18[b]
180	3.68±0.17	3.59±0.22	3.44±0.15
210	3.36±0.12	3.42±0.15	3.04±0.19
240	4.97±0.32	5.13±0.26	4.64±0.20

a and b: Means within the same row with different superscripts are significantly different at P<0.05.

Protein content

Effect of feeding the experimental rations on protein content in milk of Zaraibi goats during the suckling and milking periods is presented in Table 4 which shows that the differences among the experimental groups in protein content of goat milk were not significant during the suckling period. Similar effect was recorded during the milking period, except at 120 days of lactation (milking period), protein content was significantly (P<0.05) higher in does of G3 fed 20% SFS ration than that in does fed 15% SFS ration (G2) and control ration (G1). Generally, protein content ranged between 2.12 and 3.0% during suckling period and between 2.44 and 3.03% during milking period in all groups. The obtained results are in agreement with those observed in milk of Zaraibi goats fed rations containing 5 or 10% SFS (El-Sanafawy, 2008) or fed different types of oils (Hassan et al., 2012). Also, results available on goats (Chilliard et al., 2003) showed that milk protein content had no marked changes in goats in responses to dietary fat supplementation. Therefore, the present results may indicate that inclusion of SFS in diets of goats had no effects on milk protein. In Zaraibi goats, milk protein content ranged from 2.3-3.2% (El-Gallad et al., 1988).

Contrary to the present results, EL-Sanafawy (2008) found marked reduction in protein content of Zaraibi goats with increasing lactation month from the 1st month up to the 7th month. In Red Sokoto goats, Ehoche and Buvanendran (1983) reported that milk protein content was high in the first week of lactation, and declined rapidly to minimum values between the fourth and sixth week, after which it then increased gradually up to the end of lactation with lower variations from week to week. In Damascus, local Barki goats and their crosses, Eissa (1996) found that milk protein content decreased from the first week until the fifth to sixth week, then increased till week 16. In Jamnapari goats, significant differences in casein content in milk were found between lactation stages (Pal et al., 1996). In Murciano-Granadina goats, Fernandez et al. (2004) reported that protein content was 3.54, 3.60, 3.45, 3.53 and 3.60 at 1st, 2nd, 3rd, 4th and 5th weeks of lactation, respectively,

Lactose content

Effect of feeding the experimental rations on lactose content in milk of Zaraibi goats during the suckling and milking periods is shown in Table 5 which shows that the differences among the experimental groups in lactose content of goat milk were not significant during the suckling period, except at 90 days, lactose content was significantly (P<0.05) lower in does of G3 fed 20% SFS ration (G3) than that in those fed 15% SFS ration (G2) and control ration (G1). During the milking period, lactose content was not affected significantly by dietary treatment at all times of milking periods. Generally, lactose content ranged between 3.75 and 4.51% during suckling period and between 3.23 and 4.55% during milking period in all groups. As affected by lactation period, lactose content showed inconsistent trend of changes throughout the lactation period. However, the present findings are in agreement with those of Antunac et al. (2001), who observed higher content of lactose at the beginning of

Table 4. Effect of feeding the experimental rations on protein content (%, mean ± SE) in milk of Zaraibi goats during the suckling and milking periods.

Period	Experimental group		
	G1	G2	G3
Suckling period (day)			
15	2.95±0.13	3.00±0.07	2.94±0.06
30	2.70±0.09	2.75±0.04	2.71±0.04
45	2.49±0.10	2.53±0.03	2.73±0.07
60	2.41±0.28	2.30±0.04	2.53±0.06
75	2.53±0.10	2.39±0.06	2.54±0.05
90	2.34±0.12	2.12±0.05	2.36±0.06
Milking period (day)			
120	2.45±0.08[b]	2.44±0.06[b]	2.69±0.06[a]
150	2.64±0.11	2.42±0.09	2.63±0.06
180	3.03±0.12	2.92±0.06	2.98±0.06
210	2.84±0.12	2.62±0.08	2.79±0.06
240	3.02±0.11	2.96±0.07	2.95±0.07

a and b: Means within the same row with different superscripts are significantly different at P<0.05.

Table 5. Effect of feeding the experimental rations on lactose content (%, mean ± SE) in milk of Zaraibi goats during the suckling and milking periods.

Period	Experimental group		
	G1	G2	G3
Suckling period (day)			
15	4.51±0.05	4.51±0.06	4.33±0.07
30	4.28±0.04	4.34±0.04	4.13±0.06
45	4.10±0.05	4.14±0.04	4.12±0.04
60	3.94±0.04	3.96±0.06	3.99±0.06
75	3.87±0.04	3.91±0.06	3.79±0.06
90	3.97±0.04[a]	4.10±0.07[a]	3.75±0.07[b]
Milking period (day)			
120	3.56±0.10	3.63±0.07	3.52±0.06
150	3.38±0.08	3.36±0.05	3.23±0.07
180	4.40±0.06	4.55±0.07	4.44±0.05
210	3.93±0.08	3.95±0.06	3.95±0.06
240	3.83±0.05	3.88±0.09	3.74±0.05

a and b: Means within the same row with different superscripts are significantly different at P<0.05.

lactation than at the middle of lactation period.

Similar results were reported by El-Sanafawy (2008) and Zamfirescu (2009). However, Francisco et al. (2002) found that milk lactose decreased (P<0.05) at start of lactation period to reach the lowest value at week 5, thereafter it tended to increase gradually until the end of the lactation period.

Total solids content

Effect of feeding the experimental rations on total solids content in milk of Zaraibi goats during the suckling and milking periods is presented in Table 6 which shows significant (P<0.05) differences among the experimental groups in total solids (TS) content of goat milk only during

Table 6. Effect of feeding the experimental rations on total solids content (%, mean ± SE) in milk of Zaraibi goats during the suckling and milking periods.

Period	Experimental group		
	G1	G2	G3
Suckling period (day)			
15	13.03±0.21[a]	13.72±0.28[a]	10.24±1.72[b]
30	12.52±0.62[a]	12.75±0.30[a]	9.72±1.03[b]
45	11.63±0.38	12.17±0.25	11.57±0.32
60	12.92±0.46	11.95±0.33	11.94±0.25
75	11.90±0.39	11.45±0.30	11.41±0.24
90	11.78±0.32[a]	10.70±0.22[b]	10.71±0.13[b]
Milking period (day)			
120	10.27±0.30	10.57±0.19	10.43±0.11
150	9.30±0.21	9.83±0.09	9.37±0.19
180	11.11±0.20	11.06±0.24	10.86±0.18
210	10.13±0.11	9.98±0.17	9.76±0.25
240	11.82±0.31	12.04±0.21	11.34±0.22

a and b: Means within the same row with different superscripts are significantly different at P<0.05.

the suckling period. Within the 1st month of suckling period, only inclusion of SFS at a level of 20% in ration of goats significantly (P<0.05) decreased TS content in milk as compared to the control. However, at the last 2 weeks of the suckling period, inclusion of both SFS levels significantly (P<0.05) decreased TS content as compared to the control ration. On the other hand, TS content was not affected significantly by dietary treatment at all times of milking periods. Generally, TS content showed marked reduction in all groups in particular within the 1st intervals of suckling period.

The general trend of change in the mean total solids of goat's milk during lactation period is in full agreement with those reported by Pal et al. (1996). Wide variations in TS content were observed in different breeds of goats, being 10.7% in Alpine (Lu, 1993) and 14.9% in Beetal goats (Verma and Chawla, 1984). However, no clear differences in total solids were found between Damascus and Barki goats and their crosses (Eissa, 1996).

Fatty acids composition in milk fat

Effect of feeding experimental diets on separation condition of fatty acids (%) of milk is shown in Table 7 where the dietary treatment affected fatty acids composition in milk fat of goats. The pronounced differences in type of fatty acids among milk of different groups were in palmitoleic and linolenic fatty acids. Milk of goats fed 20% SFS ration was characterized by absence of palmitoleic acid and presence of linolenic acid. Also, feeding goats on 20% SFS ration increased total content of unsaturated fatty acids as well as long chain fatty acids in milk fat. Lipid composition is one of the most important components of the technological and nutritional quality of goat milk. Lipids are involved in cheese yield (per kilogram of milk) and firmness, as well as in the color and flavor of caprine dairy products (Delacroix-Buchet and Lamberet, 2000). Besides their quantitative contribution to the amount of dietary energy, the different fatty acids (short- and medium-chain, saturated, branched, mono- and polyunsaturated, cis and trans, conjugated) are potentially involved as positive or negative predisposing factors for the health of human consumers (Williams, 2000).

The peculiarities of goat milk lipolytic system and medium-chain fatty acids could greatly change the content in free fatty acids, playing a major role in the occurrence of the characteristic goat flavor. The response of milk fatty acid composition is nearly similar, in particular for major fatty acids, including conjugated linoleic acid (CLA) in milk of goats in all groups. Chilliard et al. (2003) observed that for goats fed diets supplemented with either protected or unprotected lipids, milk CLA content increases sharply after either vegetable oil supplementation or fresh grass feeding, but does not change markedly when goats receive whole untreated oilseeds. Important interactions are observed between the nature of forages and of oil supplements on trans-10 and trans-11 C18:1 and CLA.

Griinari et al. (1998) reported that changes in the non-glucogenic ratio of VFA will depress acetate production and *de novo* synthesis of short chain fatty acids in the mammary gland and direct inhibition of milk fat synthesis can result from the production of partially hydrogenated

Table 7. Effect of feeding experimental diets on separation condition of fatty acid (%) of milk.

Fatty acid (%)		Experimental group		
		G1	G2	G3
C4	Butyric	4.237	4.520	4.76
C6	Isocaproic	6.787	6.80	7.11
C10:0	Capric	10.057	10.05	10.193
C12:0	Lauric	11.733	11.73	11.605
C14:0	Myristic	12.633	12.557	12.78
C16:0	Palmitic	13.60	13.60	13.56
C16:1	Palmitoleic	13.983	14.133	0.000
C18:0	Stearic	16.962	16.975	16.877
C18:1	Oleic	17.533	17.517	17.395
C18:2	Linoleic	18.377	18.367	18.627
C18:3	Linolenic	0.00	0.00	19.485
Total saturated fatty acids		76.009	75.962	76.885
Total unsaturated fatty acids		49.893	50.017	55.507
Short chain fatty acids (<C14)		32.814	32.83	33.668
Medium chain fatty acids (C14:C17)		40.216	40.29	26.34
Long chain fatty acids (>C17)		52.872	52.859	72.384

fatty acids. The reduction in fat mobilization decreased the availability of plasma NEFA, especially C18:0 and C18:1, for mammary lipid synthesis. These fatty acids did not differ in response to dietary treatment. Furthermore, many authors stated that the response to feeding different kinds of unprotected lipid supplements consisted mainly of an increase in the percentages of milk C18:0 and C18:1, at the expense of mainly C8 to C14 and C16:0 (Schmidely and Sauvant, 2001). This was probably due to the ruminal hydrogenation of polyunsaturated fatty acids into C18:0 and trans-C18:1, which are inhibitors of the *de novo* FA synthesis, mainly C8 to C16. The final response of milk C16:0 percentages depended on the level of dietary intake, that is, the C16:0 percentages in the lipid supplement which was studied. Therefore, the present similarity in fatty acid composition and slight increase in total unsaturated fatty acids in milk of goats fed 20% SFS ration may indicate the safe use of SFS up to 20% without adverse effects on hydrogenation of fatty acids in rumen and consequently marked changes in fatty acid composition in milk fat. Changes accompanied by C16:1 and C18:3 are mainly due to their proportions in SFS. A similar conclusion was reported by Bernard et al. (2005). However, saturated fatty acids of C16 and C18 had little effect on milk fatty acid profile (Harvatine and Allen, 2006). In the present study, the higher proportions of C18:3 in milk of does fed 20% SFS ration are responsible for the lack of differences in C18:0 and C18:1. Chilliard and Ferly (2004) indicate that C18:3 is often hydrogenated into C18:0, while hydrogenation of C18:2 gives rise to different isomers of C18:1.

Milk somatic cells count (SCC × 10^3)

Means of somatic cells count (SSC) during different lactation stages (suckling and milking periods) in the milk of different groups are shown in Table 8. Results indicated that milk SCC was significantly ($P<0.05$) lower in milk of does fed 15% SFS ration (G2) than that of those fed 20% SFS ration (G3) and control one (G1) during different times of the suckling and milking periods. However, the differences in SSC between G3 and G1 were not significant, except at 15 and 120 days. Throughout the lactation period, SSC showed inconsistent trend of change in all experimental groups. It is of interest to note that values of SSC presented in this study for all groups are higher than that reported in milk of goats. This may reflect a higher incidence of infection; however, information on incidence of mastitis in this study was not available.

In this concern, Lerondelle and Poutrel (1984) determined SSC using a Coulter counter. They indicated that the SCC in uninfected halves of goat mammary glands ranged from 0.470 to 2.7 × 10^6 cells/ml. Intramammary infection in one udder half of goats increased SCC in the corresponding uninfected half, which could be an important factor in milk quality testing.

In accordance with the present results, Cerón-Muñoz et al. (2002) found that SCC decreased in the second month of lactation and increased thereafter up to the ninth month of lactation. Also, Farghaly (2002) showed that stage of lactation significantly affected milk SSC, since both the original and logarithm milk somatic cells were the highest shortly after calving dropped to a minimum between 40 and 80 days postpartum and then steadily increased until the end of lactation. In addition, the changes in SSC in milk of goats may be associated with seasonal variation.

Hinckley (1991) observed the lowest SCC in milk of goats in April and the highest values in September-

Table 8. Effect of feeding experimental diets on somatic cells count (× 103, mean ± SE) of milk during the suckling and milking periods.

Period	Experimental group		
	G1	G2	G3
Suckling period (day)			
15	914.6±0.71[a]	456.3±0.69[b]	430.9±0.75[b]
30	708.8±0.71[a]	197.8±0.69[b]	940.5±0.75[a]
45	455.6±0.69[a]	231.9±0.69[b]	567.5±0.69[a]
60	764.2±0.69[a]	323.8±0.69[b]	605.4±0.69[a]
75	894.0±0.69[a]	302.2±0.69[b]	958.3±0.69[a]
90	1580.7±0.69[a]	662.3±0.69[b]	1328.6±0.69[a]
Milking period (day)			
120	2598.4±0.69[b]	2046.6±0.69[b]	2697.3±0.69[a]
150	676.1±0.68[a]	214.7±0.71[b]	689.9±0.69[a]
180	512.1±0.68[a]	263.4±0.71[b]	814.9±0.71[a]
210	786.0±0.68[a]	167.0±0.75[b]	969.5±0.71[a]
240	861.6±0.08[ab]	220.1±0.75[b]	1511.7±0.71[a]

a and b: Means within the same row with different superscripts are significantly different at P<0.05.

October. However, in another study with goat milk bulk tank samples, SCC did not appear to be affected by seasonal variation. Seasonal variation may reflect the number of fresh to mid and late lactation does because goats breed seasonally. Similar results were obtained by Rodriguez et al. (2000), who reported that season had significant effect on milk somatic cells count. Zhang et al. (1994) found that the highest SCC occurred during summer season. Dakic et al. (2006) stated that stress from winter cold and summer hot period had considerable influence on somatic cells count to increase in cow milk and therefore it causes considerable milk quality decrease. Furthermore, SSC in milk during winter season was higher than limit levels stated by Djabri et al. (2002) and Hamann (2002). The reasons for seasonal variations are unknown and only speculated to be the effects of housing, rain and temperature changes on infection status. Based on the foregoing results of milk production, increasing level of dietary inclusion of SFS to 20% showed pronounced improvement in milk yield as average daily milk yield during the suckling and milking periods. Both levels of SFS inclusion had no marked effect on approximate chemical composition and composition of fatty acids in milk fat. However, 15% SFS level showed considerable reduction in SCC in milk of goats.

Histological changes in mammary gland

The histological examination of specimens of the mammary gland of Zaraibi goats showed normal architecture of the mammary gland in all experimental groups; however, some differences were observed as affected by dietary treatment or lactation period in terms of number and size of milk alveoli, number and volume of secretory cells, size as well as area of the mammary stroma (connective tissues).

During the suckling period

During the suckling period, the histological examination of pre- or post-milking revealed normality in the histological structure of the mammary gland of different experimental groups as affected by dietary treatment with marked differences, among experimental groups and even between pre- and post-milking within the same group, in volume, density, thickness and number of epithelium, and lumen diameter of milk alveoli as well as thickness of connective tissues (adipose tissues or stroma) as illustrated in Plates 1 and 2.

Pre-suckling, as a result of presence of milk in alveolar system within the alveolar lumen, milk alveoli were seen to be bigger, more compacted with wider lumen, and thinner and numerous epithelial cells in mammary gland of does fed 15 and 20% SFS than in the control does. Also, thickness of connective tissues and consequently the amount of adipose tissues or stroma was less in the mammary gland of does fed 15 and 20% SFS than in the control does (Plate 1). Such findings are in accordance with milk yield of goats in different experimental groups. During lactation, milk is synthesized within the alveolar compartment and its amount depends on the activity and number of the mammary epithelial cells (MEC). Cells number in the mammary gland is the function of the rates of cells proliferation and cells death. The mammary gland grows when the rate of proliferation exceeds the rate of death, and it regresses when the rate of death exceeds the rate of cells proliferation (Capuco et al., 2001). In addition, a close correlation between milk yield and the amount of secretory tissue has been reported in ruminants (Baldi et al., 2002). Nutrition affects mammary development during pregnancy and lactation in ruminants. During early lactation, mammary proliferation is proportionally greater in species that exhibit less negative energy balance (Stefanon et al., 2002). Deficiencies in the dietary supply of specific amino acids (histidine, methionine and lysine) in early and late lactation, markedly reduced milk yield with no clear evidence of corresponding changes in measurements of mammary cells number, activity or proliferation rate (Yeo et al., 2003). After suckling, the histological examination of the mammary gland revealed that milk alveoli in all experimental groups were smaller, denser with narrow lumen and thicker epithelium than that observed for pre-suckling. Moreover, thickness of connective tissues and consequently the amount of adipose tissues or stroma was higher in the mammary gland of does in all groups of post-suckling than pre-suckling. However, thickness of epithelium was the highest in the mammary gland of does fed 20% SFS (Plate 1). These observations are in association with removal of milk in alveolar system of goats in different experimental groups.

During the milking period

During the milking period, the histological examination of pre-milking revealed normality in the histological structure of the mammary gland of different experimental groups as affected by dietary treatment with marked differences between does fed 20% SFS diet and those fed 15% SFS and the control diets. Generally, the mammary gland of does fed 20% SFS diet showed milk alveoli with higher volume, density, thickness, number of epithelium, and lumen diameter of milk alveoli than those observed in the mammary glands of does fed 15% SFS and control diets (Plate 2).

Since the activity of mammary cells did not decrease as lactation advanced in non pregnant animals, the main reason for milk decline during late lactation appeared to be the reduced MEC number. However, during late lactation, when animals were concomitantly lactating and pregnant, the secretory activity per cell also declined due to conflicting metabolic demands of gestation and lactation (Capuco et al., 2003). In accordance with the differences in the histological structure of the mammary gland of goats between suckling (early lactation period) and milking period (late lactation period), Capuco et al. (2001) observed that the increase in milk yield until lactation peak (from week 3 to week 8 in goats, and from week 2 to week 13 in cows) appeared to be due to increased synthetic capacity of the MEC (hypertrophy), rather than an increase in number of secretory cells. The progressive decline in milk yield after peaking during suckling period was associated with a decrease in the total DNA content of the mammary parenchyma, representing a net fall in cells number (Capuco et al., 2001). Mammary gland in goats can grow during early lactation. This growth during early lactation is important; for instance, gestational mammary development can be reduced experimentally with no deleterious effects on subsequent milk production. In the same manner, this may occur in goats. However, during the late lactation (involution), the connective tissue increased concomitantly with the regression of the alveoli into the smallest size and reduced frequency of secretory cells (Plate 3). At the late lactation (suckling), the DNA frequency was lower than during milking (Plates 1 and 3); this case is in agreement with the study of Capuco et al. (2001) and Hassan (2004), who reported, in cattle and buffalo, respectively, that the content of parenchymal DNA was the greatest at day 14 of lactation and declined to a low level at day 240. Also in sheep, the high content of DNA at the early stage of lactation indicated a high correlation between mammary cells number and milk yield. The highest amount of DNA at mid lactation indicates the greatest number of secretory cells with the high activity of lactation.

Economic efficiency of milk production

Data of economic evaluation of feeding the experimental rations on milk production during the whole lactation period (suckling and milking periods) are presented in Table 9. The present results revealed that milk / feed efficiency and feed conversion for concentrates was the best for does fed 20% SFS ration, followed by those fed 15% SFS ration, while those fed the control ration showed the poorest values. Cost of each kg milk was the lowest (1.44 L.E.) for does fed 20% SFS ration, the modest (1.59 L.E.) for those fed 15% SFS ration and the highest (2.02 L.E.) for the control does. Such trend was reflected in the highest economic efficiency of milk production in does fed 20% SFS ration, followed by those fed 15% SFS and control rations (299.1, 207.5 and 150%, respectively). This was mainly attributed to feed efficiency and feed conversion to milk in each experimental group. Similar trends were obtained by El-Sanafawy (2008) on goats fed 5 and 10% SFS rations, which may indicate that increasing replacement of concentrate feed mixture containing cotton seed cake by sunflower seeds from 5 to 10% increased economic efficiency of milk production.

Price of concentrate feed mixture, fresh berseem, berseem hay and sunflower seeds were 2000, 100, 500 and 2600 L.E./ton, respectively, while price of ton milk was 3300 L.E. All prices were used according to the marketing price during the experimental period (2010).

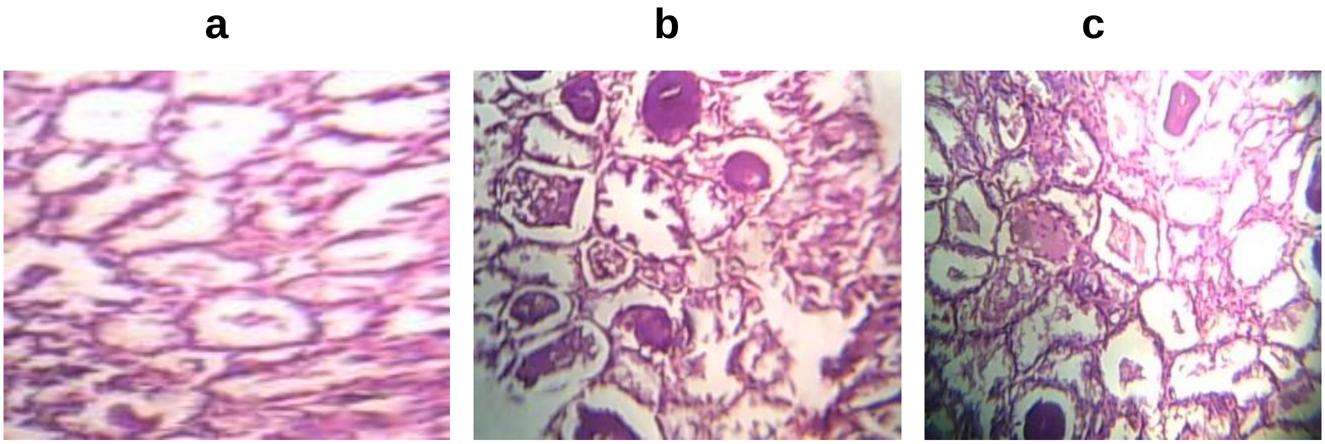

Plate 1. Sections in pre-suckling mammary gland of goats in different experimental groups. (a) Goats fed the control ration; (b) Goats fed 15% SFS ration; and (c) Goats fed 20% SFS ration.

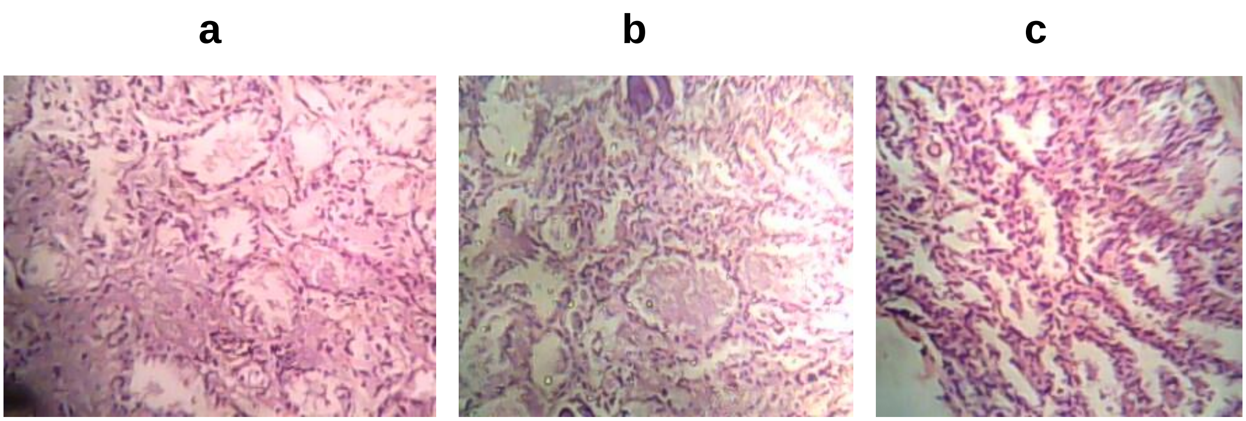

Plate 2. Sections in post-suckling mammary gland of goats in different experimental groups. (a) Goats fed the control ration; (b) Goats fed 15% SFS ration; and (c) Goats fed 20% SFS ration.

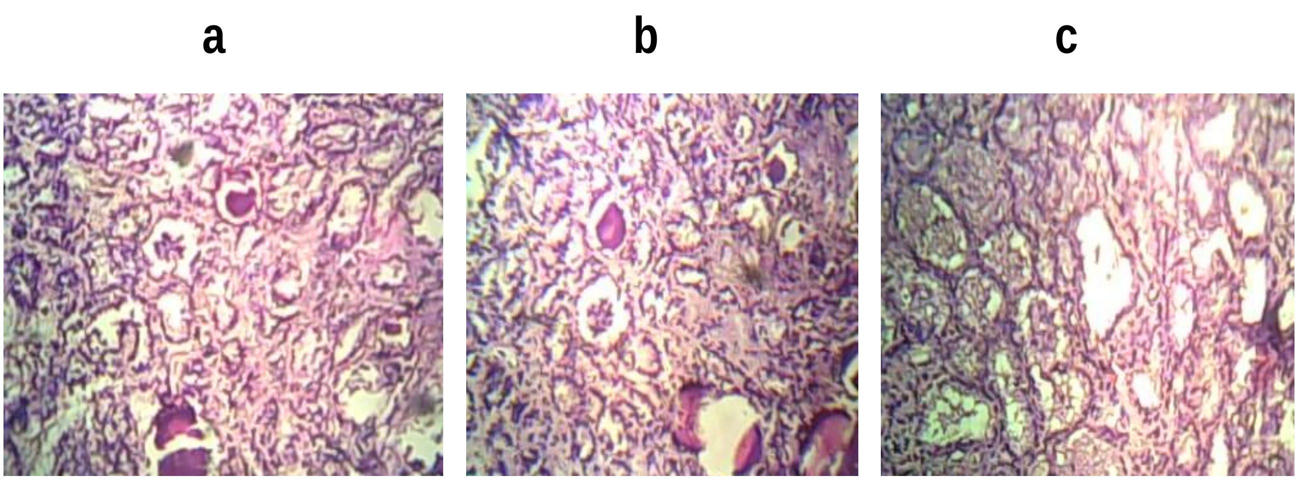

Plate 3. Sections in pre-milking mammary gland of goats in different experimental group. (a) Goats fed the control ration; (b) Goats fed 15% SFS ration; and (c) Goats fed 20% SFS ration.

Table 9. Economic efficiency of milk production in different experimental groups during the lactation period.

Item	Experimental group		
	G1	G2	G3
Total concentrate feed mixture (kg/doe)	300	255	240
Total sunflower seeds (kg/doe)	-	45	60
Total concentrates (kg/doe)[1]	300	300	300
Total milk yield (kg/doe)[2]	363.15	479.34	534.81
Feed efficiency (kg milk/kg concentrate)[2/1]	1.21	1.59	1.78
Feed conversion (kg concentrate/kg milk)[1/2]	0.826	0.625	0.561
Total fresh berseem (kg/doe)	750	750	750
Total berseem hay (kg/doe)	120	120	120
Cost of feeding the total ration (L.E.)	135	135	135
Cost of feeding sunflower seed (L.E.)	-	117	156
Cost of concentrate feed mixture (L.E.)	600	510	480
Total cost feeding (L.E.)[3]	735	762	771
Feeding cost of producing kg milk (L.E.)[3/2]	2.02	1.59	1.44
Economic efficiency (EE%)	163.05	207.5	228.91
EE (%) relative to control	100	127.26	140.39

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